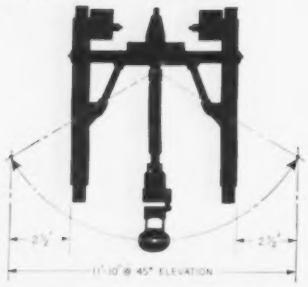
THE EXPLOSIVES ENGINEER

FORE-RUNNER OF PROGRESS IN
MINING-QUARRYING & CONSTRUCTION

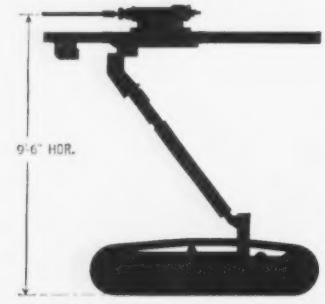
JULY-AUGUST · 1959

VOLUME 37 · NUMBER 4

MORE SWING



...MORE REACH



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THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

A great project that will have a profound effect on the Pacific Northwest is the building of three dams by the Idaho Power Company. The dams are the Brownlee, the Oxbow, and the Hell's Canyon, which, when completed, will produce more than 1,000,000 kw. of electrical energy plus such other benefits as flood control and recreation.

In this issue, starting on page 103, Robert J. Brown describes the project, giving special attention to the Brownlee Dam on the Snake River. This dam, constructed by Morrison-Knudsen Company, Inc., of Boise, Idaho, has the world's second-highest rockfill embankment. Its generating equipment, now in full production, supplies electrical power to a vast area.

° ° °

For a number of years, the Delaware River has had a deep channel from the breakwater to Philadelphia that was navigable for great ocean-going vessels. Because of this, the harbor areas on each shore almost reached the saturation point with great oil refineries, chemical plants, shipyards, and other industrial enterprises.

To open up a new and almost untouched area, the U. S. Army Corps of Engineers decided to make a 40-ft.-deep channel so that the large cargo carriers could navigate in safety between Philadelphia, Pennsylvania, and Trenton, New Jersey. The contract for the area, known as Section R-1B—Mud Island Range, was awarded to American Dredging Company. Everett F. Diehl, in his article starting on page 112, tells of the procedures and the precautions taken to keep blasting noises and vibrations to the extremely low level set by the Corps of Engineers.

° ° °

In the quarry of the Quartzite Stone Company in Lincoln County, Kansas, a curious stone formation exists. The formation is extremely hard, has occasional loosely packed sand pockets, and usually rests on a sand floor. The limestone quarried at this operation is suitable for concrete aggregate, and Quartzite's operation is one of the very few quarries in western Kansas producing rock suitable for this use.

Blasting in this type of formation requires thoughtful planning if production costs are to be kept to a minimum. Farrell Castellani, an explosives engineer of many years' experience, describes the operation, giving special emphasis on the drilling and blasting techniques used. The article starts on page 118.

° ° °

Today, industrial explosives are being used in so many and varied fields that one is seldom surprised to read of a new industrial application.

An application that has lately been receiving more than cursory attention is the forming of metal shapes by explosives. Engineers in the aircraft industry, who detonated explosives immersed in water, found this a quick and economical method of forming complex shapes. For an account of one aircraft manufacturer's successful experience, please turn to Thomas A. Dickinson's article on page 122.

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

EDITORIAL STAFF: James J. O'Neill, *Managing Editor;* Thomas E. Miller, *Contributing Editor;* Gertrude A. Donnelly, *Associate Editor;* Edward L. Grant, *Art Editor;* Howard B. Dickson, *Production Manager;* Charles E. Rabenold, *Advertising Manager;* Montgomery R. Budd, *Director.*

SUBSCRIPTION RATES: *United States and Canada*—One Year, $1.50; Single Copies, $.30; *Limited Subscriptions Only to Other Countries*—One Year, $2.50; Single Copies, $.50.

The Explosives Engineer, 613 Delaware Trust Building, Wilmington, Delaware. Printed in United States of America.

PUBLISHED BY *HERCULES POWDER COMPANY*

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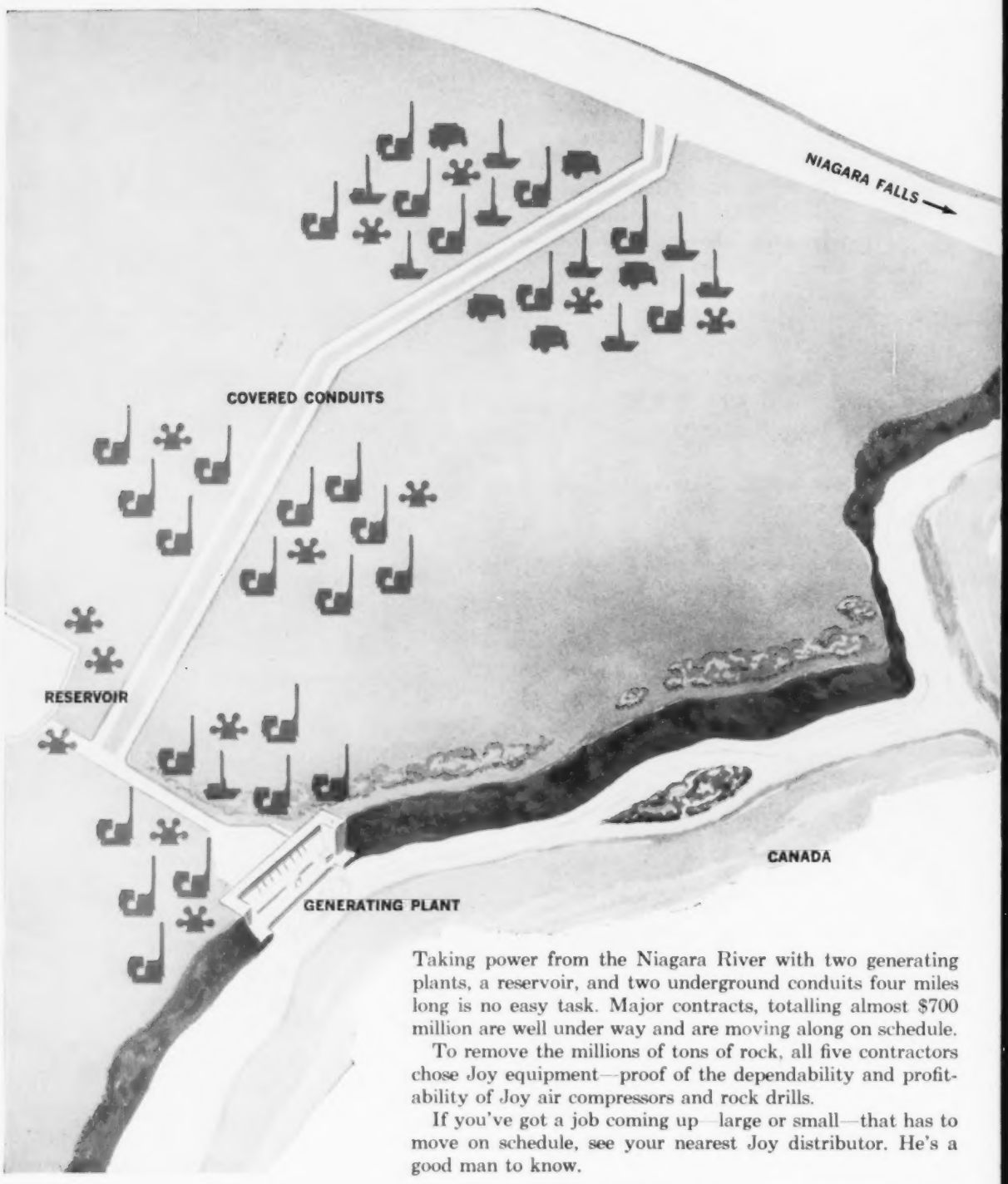
VOL. 37 NO. 4 JULY-AUGUST, 1959 BPA

JOY EQUIPMENT

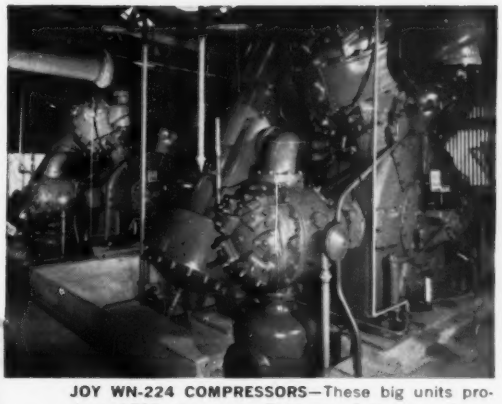


Taking power from the Niagara River with two generating plants, a reservoir, and two underground conduits four miles long is no easy task. Major contracts, totalling almost $700 million are well under way and are moving along on schedule.

To remove the millions of tons of rock, all five contractors chose Joy equipment—proof of the dependability and profitability of Joy air compressors and rock drills.

If you've got a job coming up—large or small—that has to move on schedule, see your nearest Joy distributor. He's a good man to know.

chosen for Niagara, one of world's largest rock removal jobs



JOY WN-224 COMPRESSORS—These big units produce 3700 cfm each. Thirteen of these package-type machines are being used by four contractors. Notice the compact design and the simple, relatively light foundations. Installation was quick and easy because the compressors arrived at the site completely assembled.

JOY RP-900 ROTARY PORTABLE COMPRESSORS—These portables are big and rugged—supply 900 cfm each. Even in Niagara's extreme weather, a thermal by-pass valve in the oil cooler system assures adequate lubrication in cold weather. Joy rotaries operate in low temperatures that would keep other portables shut down.

TWENTY-SIX LARGE DRILLS USED . . . JOY CHALLENGERS—With cuts as deep as 200 feet to make, the Niagara job requires big drills. Twenty-six of these Joy TWM-5 Challengers are being used. Mounting the powerful 630 lb. TM-500 drifter drill, the Challengers are punching 4" and 4½" holes down to 30' deep without a steel change.

JOY TDM TRAC-DRILLS—Eight of these fast-moving TDM's mounting TM-450's and TM-500's are being used, along with nine Joy wagon drills that mount the Joy TM-400 drifter. These TRAC-DRILLS work right alongside the larger Joy Challengers, drilling 3½" and 4" holes.

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W. Trent Ragland, Jr.

PRESIDENT

SUPERIOR STONE COMPANY

A Biography

W. TRENT RAGLAND, JR., president of the Superior Stone Company, Raleigh, North Carolina, might be described as a seagoing quarryman, for he served with distinction on the staff of Admiral Chester W. Nimitz, commander in chief of the Pacific Fleet in World War II. Modest to a fault, Trent Ragland disclaims any great credit for his tour of duty, but the Navy thought well enough of him to advance his rank from ensign to lieutenant jg, and gave him an honorable discharge with the rank of lieutenant.

Trent was practically born in a quarry. His father, who founded the Superior Stone Company, saw that he became familiar with quarries, and put him in his first job as office boy in the main office of the Raleigh Granite Company in the summer of his fifteenth year. By the age of eighteen he had graduated to a budding quarryman at the Red Hill, Virginia, quarry of Superior Stone.

Trent attended the Raleigh, North Carolina, public schools and the Woodberry Forest School at Orange, Virginia. In 1937 he entered Virginia Military Institute at Lexington, Virginia, and, the following year, the University of North Carolina, from which he graduated in 1941 with a B.S. degree in geology. At college he was president of his fraternity, Zeta Psi, and of the Order of Gimghoul. Immediately after his graduation he went to work at the Belgrade Quarry of Superior Stone, working in the office. After a year here, however, the war swept him into the United States Navy.

Mr. Ragland entered the service in the spring of 1942 at Norfolk, Virginia, and was an ensign when assigned to Admiral Nimitz's staff. Trent seems to have had plenty of interesting experiences. The day he arrived the base intercepted a Japanese dispatch which, when decoded, disclosed that an enemy fleet was departing for an attack on "either Midway or Pearl Harbor." As we know, the Japanese decided while en route to strike at Midway.

After two years in the Pacific arena on Nimitz's staff, Trent was sent to Annapolis for a postgraduate course at the Naval Academy. This course for line officers covered navigation, damage control, gunnery, war plans, and logistics with considerable emphasis on communications. Upon completion of the course, he was assigned to the carrier *Saginaw Bay*, but saw no action as the war was almost over by that time.

Discharged in October, 1945, he headed back to the quarries, and became sales manager of the Kings Mountain Plant of Superior Stone. He was elected a vice president and director in 1947 and managed the affairs of the company in western North Carolina until 1953 when he moved to Raleigh. He was elected president the following January.

Last April 21, Superior became an operating division of the American-Marietta Company, the long-established North Carolina company becoming the Superior Stone Company Division of the parent company. At the time of the merger, Superior operated twenty quarrying and processing plants in Virginia, North Carolina, South Carolina, and Georgia.

Superior's sales go primarily to highway-construction programs, which have been moving ahead rapidly in its four-state territory, where it is a leading supplier of aggregate for a ready-mix concrete industry.

As the principal executive officer of Superior Stone, Trent Ragland soon will join the board of directors of American-Marietta.

Trent is an active participant in his community's affairs. He has served on the board of the National Crushed Stone Association since 1949. He is a director of the Wachovia Bank and Trust Company of Raleigh, the North Carolina Engineering Foundation, the United Fund, and the Y.M.C.A. of Raleigh; a member of the executive committee of the Rex Hospital Foundation; and treasurer of the Layman's League of the Church of the Good Shepherd.

Among his clubs he numbers the Carolina Country Club, the Rotary Club of Raleigh, and he is president of the Sphinx Club.

Trent married Anna Wood of Edenton, North Carolina, in 1944, and they now have three children: Anna Wood, Alice McKenzie, and William Trent III. They live at 1002 Cowper Drive, Raleigh.

W. TRENT RAGLAND, JR.

Editorial

Our Most Vital Resource

Water in the United States is gradually taking on the status of a national problem. The statistics brought forth by industry, the Government, and other forward-looking people are anything but reassuring.

The Census Bureau points out that by 1980 U. S. population will be 260 million, and will be double our present population by the year 2000. As industry expands with this growing market, its take of water will increase at least proportionately. Finally, in many areas where extensive use has been made of underground water, the water table is dropping alarmingly. Truly, water has become a national problem, and planning now for the future may prevent it from becoming a national emergency.

Two Government units, among others, are doing something about it. The State of California has recently launched one of the biggest construction projects ever undertaken anywhere in the world, the Feather River Project, just approved by California voters. Destined to cost $2 billion, it will overshadow even such monumental projects as the Tennessee Valley Authority and the St. Lawrence Seaway. Meanwhile the United States Bureau of Reclamation has begun the Colorado River Storage Project, estimated to cost $1 billion, to bring water to perhaps the most arid region in the continental United States.

The Reclamation Bureau reports it is studying the possibilities in other approaches to the water problems besides building bigger and bigger dams and canals. One prospect is the reduction of seepage, waste, and evaporation. A second hope is the location and better utilization of underground water supplies. A third is the conversion of sea water for industry and municipal drinking water. Another is increased precipitation by artificial means—the cloud-seeding or rain-making idea. These are worthy efforts, some of which may prove fruitless, and surely they merit our intensive study.

Most assuredly, water is going to loom larger in the plans of Americans in the next several decades. The construction industry will find more proposals for dams, tunnels, and canals; while mining, agriculture, our great municipalities, and, in fact, the whole population will look upon water as that most vital of nature's resources. The nation will do well to look forward to the day when more water will be needed, and to begin now to provide for that day.

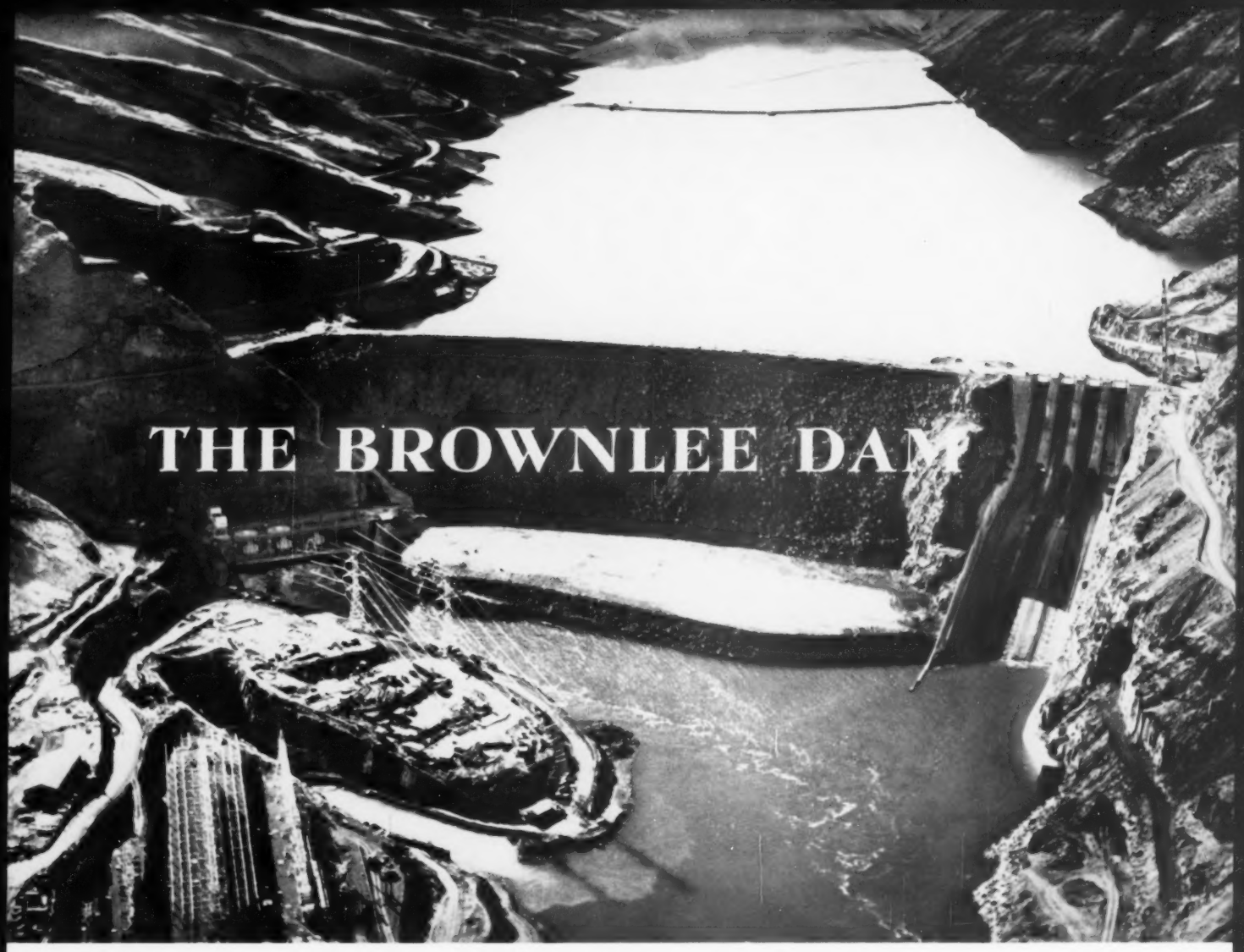
"The Glory That Was Greeee"

The ancient Greeks conceived of progress as a closer and closer approach to perfection, but they paid little attention to the idea, inherent in our conception of progress, of expansion, extension, or growth in size. In contrast, 2,000 years later John Stuart Mill gave the Western world a philosophy which expressed progress in terms of "the greatest good for the greatest number."

These two philosophies might be applied to our progress in safety in the mines and quarries of the country. The National Safety Competition has an unparalleled record of progress of which our mineral industries can be proud. In the 34-year history of this competition, the injury-severity rate and the injury-frequency rate have followed an almost constantly declining trend. The 1958 competition continued this excellent progress, for the severity rate was the fourth lowest rate of any year on record and the frequency rate was the second lowest rate for any year. This is most assuredly a closer and closer approach to ultimate perfection, which would mean no injuries whatever in any U. S. mine or quarry.

Our attention, however, has been caught by another statistic in this competition: the fact that last year 675 mineral operations enrolled in the competition, the highest of any year on record. This is more in line with Mill's concept of progress and one that we like to see emphasized, for it means more operations, more miners and quarrymen enrolled in this safety effort. The two ideas of perfection and growth are not incompatible by any means. Both would like to see as many injuries avoided as possible. Neither would minimize the perfect safety record of a mine or quarry.

As the United States Bureau of Mines men have stated publicly so often, the history of the competition shows that operations enrolled in it have consistently had a better safety record than mines and quarries not enrolled. We think it is all to the good that more mines and quarries should be enrolled in this competition because we believe more lives will be saved, more injuries avoided, and the cause of safety advanced. Let us try to keep the frequency and severity rates down, but let us also try to get more mines and quarries enrolled in this great safety effort. The competition is already on the way up in numbers; we should not stop until every U. S. mine and quarry is enrolled.



THE BROWNLEE DAM

BROWNLEE DAM: Aerial view of completed Brownlee Dam shows world's second highest rockfill embankment. The powerhouse is in the deep rock cut on the left, while the spillway is shown at the right. A flat-topped island of natural rock separates embankment and spillway.

A gigantic hydroelectric project taking form along the Snake River in Idaho will aid in the further development of the Pacific Northwest

ROBERT J. BROWN, JR.*

THEIR boats tossed like eggshells by the wild water, French *voyageurs* with the Astor expedition of 1811 hurled outraged words at the mountain-hemmed stretch of the Snake River.

"Accursed, mad river," they shouted.

And with good reason. For that tortured reach of river was what now is known as Hell's Canyon—a remote and rugged chasm between Idaho and Oregon where the Snake runs 100-odd miles in tumbling fury toward the sea.

North America's deepest gorge, the Hell's Canyon reach was etched into the face of the land through eon upon eon of time. Here on the continent's western slopes, so geologists say, lava flows overran the region. Vomited from the earth's molten belly, lava streams piled on lava streams, cooled, and were chiseled by wind and water into forbidding mountains. On the canyon's Idaho side were fashioned the Seven Devils. He Devil and She Devil peaks tower nearly 9,500 ft. above sea level; the five smaller Devils rise to lesser, but still dizzying, heights. On its Oregon side, the Wallowa range's regal "Matterhorn" reaches 10,000 . . toward the sky.

Legend relates that the Seven Devils earned their name from the tale of an Indian who became separated from a hunting party and wandered many miles through the canyon wilderness searching for his companions. Exhausted and hungry, he imagined he saw a devil peering at him, then another and another until there

*6610 Ustick Road
Boise, Idaho

CORE DRILLING: Extensive core drilling was done to determine the nature of the rock that would be encountered in the embankment area.

were seven. Pioneers who later heard of the brave's experience named the mountains the Seven Devils.

Between these lava peaks, flowing seaward from its shadowy headwaters in the majestic mountain ramparts of Wyoming's Tetons, the Snake River inexorably carved the Hell's Canyon reach. The gorge, broad at its entrance, narrows at one point to only 100 ft. where the rock-studded stream boils nearly 8,000 ft. below the top of almost sheer cliffs.

Here it was, in early-day tests of men against the river, that heroes were made. Surely such were the 64 men of the Wilson Price Hunt party, thought to be the first whites to push into the pitiless and punishing wilderness as they pioneered the Oregon trail. Once, with the expedition split by the disastrous loss of its boats, one group cooked a fresh-killed horse on one side of the savage stream while the other group "hovered like specters of famine" on the opposite bank, isolated as though in another world by the raging river.

And it is here, in latter-day tests of men against the river, that Idaho Power Company and its contractor, Morrison-Knudsen Company, Inc., now are harnessing the Snake with a new hydroelectric development. Consisting of three dams, the progressive, multipurpose development has struck sparks from the imaginations of men around the world and fueled the fires of controversy in Congress and across the nation.

Three Dams Undertaken

Idaho Power's trio of dams—Brownlee, Oxbow, and Hell's Canyon—ultimately will produce more than 1,000,000 kw. to help nourish the progress and prosperity of the Pacific Northwest. Estimated total cost of the entire three-dam development, including transmission lines and related facilities, is about $164,000,000. The three river-harnessing projects have been licensed by the Federal Power Commission and, in addition to their great output of electricity, will provide public benefits of flood control, navigation, and recreation. Ultimately, the development will yield $10,000,000 annually in new federal, state, and local tax revenues.

The utility also is installing a multi-million-dollar system of complex migrant fish facilities to conserve both upstream and downstream runs of salmon and steelhead. The only two-way system at any project on the Columbia and the Snake Rivers, it includes an experimental downstream-migrant facility in Brownlee's reservoir, the first of its kind ever built. Chief features of the unique installation are a plastic-mesh net measuring 2,800 ft. long and 120 ft. deep, and three novel "skimmers," or barges, that safely scoop the fingerlings from the reservoir.

Brownlee Produces 360,000 kw.

Brownlee, which boasts the world's second-highest rockfill embankment, now is in full production with its initial capacity of 360,000 kw. The first of its initial four generating units went "on the line" in August, 1958, and the fourth big 90,000-kw. unit spun into action last January. Only such routine tasks as painting and landscaping remain to complete the mammoth project.

One of the biggest armies of men and machines ever assembled pushed Brownlee to completion in far less time than is normally required for a project of such magnitude. At the peak of Brownlee construction, the number of workers hit 3,400, toiling around the clock seven days a week. The monthly payroll for this force totaled some $2,500,000.

Main construction effort at Idaho Power's ambitious development now is focused on Oxbow Dam, a 190,000-kw. producer located 12 miles downstream from Brownlee where the Snake sweeps around a scenic horseshoe bend between towering mountains. This second of the utility's new dams also will have a rockfill embankment—205 ft. high and flanked by two concrete spillways. Water trapped by the dam will be funneled to the powerhouse through two tunnels piercing the neck of the rocky promontory that creates the horseshoe bend.

Preliminary work already has started on Idaho Power's Hell's Canyon Dam, 23 miles downstream from Oxbow.

Third unit in the bold new development to harness the wasting waters of the wilderness gorge, the Hell's Canyon project is scheduled to swing into actual construction following Oxbow's completion. It will have an installed capacity of 272,000 kw.

Controversial Issue

Scene of bustling construction activity and achievement for more than three years now, the Hell's Canyon reach also has been the battleground for a struggle between private- and public-power supporters for much longer than that.

The struggle dates back to 1947, when Idaho Power filed a preliminary application with the Federal Power Commission for the Oxbow project. Public-power supporters quickly called for the Federal Government to develop the reach with a so-called "high" Hell's Canyon Dam. And the battle was on.

During the following years, while the utility amended its application before the FPC to include Brownlee and its own Hell's Canyon Dam as well as Oxbow, Idaho Power's opponents continued their drive for Federal development. They fostered no fewer than 20 congressional bills providing for the high dam, all of which failed to win sufficient support. Numerous hearings were held to give voice to both sides of the controversy. One of them was the longest hydro-project hearing in FPC history, producing a record totaling 19,215 pages and more than 400 technical exhibits.

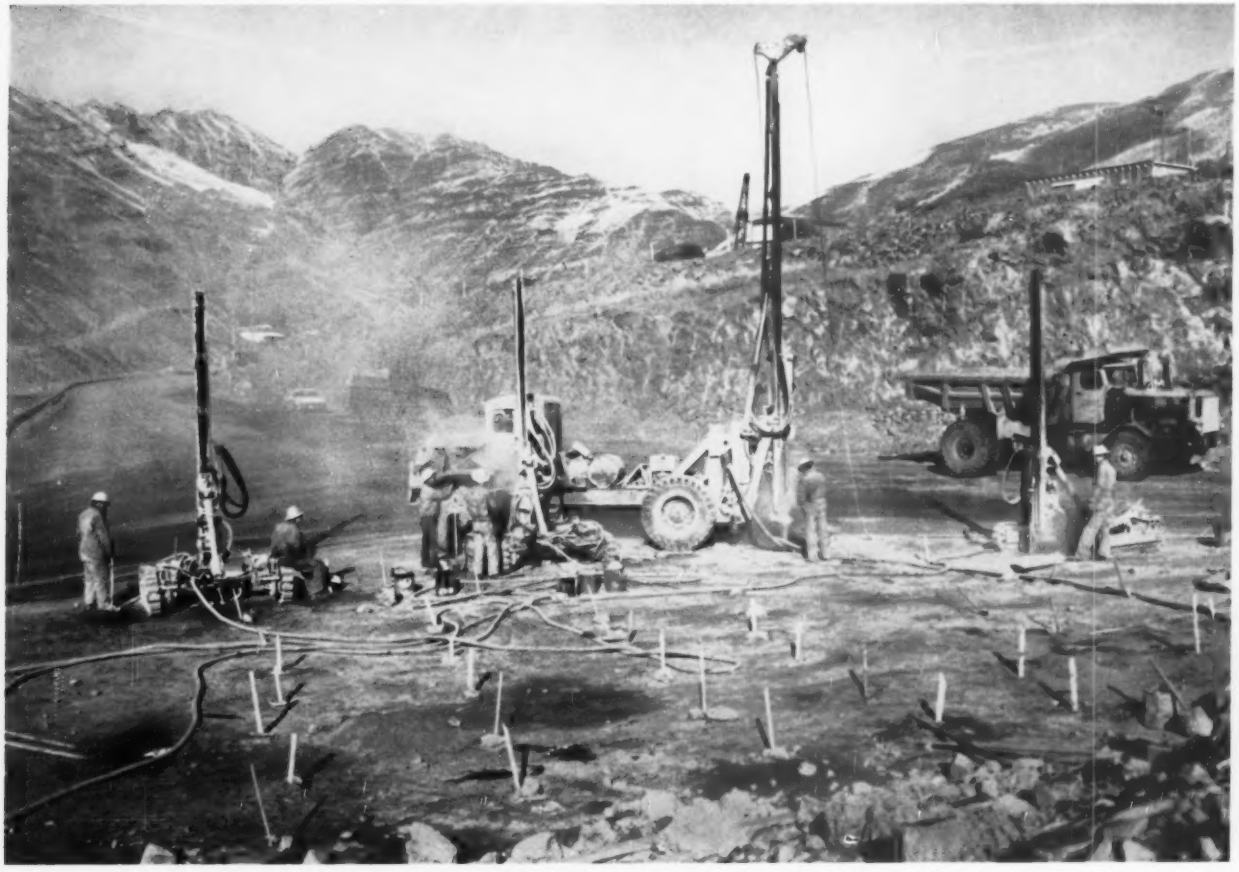
Idaho Power Company Granted License

On August 4, 1955, in a unanimous decision, the FPC issued a license giving Idaho Power the green light for construction of its Brownlee, Oxbow, and Hell's Canyon projects. Public-power supporters were to continue their efforts for Federal development (including an unsuccessful appeal to the U. S. Supreme Court), but the utility moved swiftly to start its program for harnessing the Snake. On November 9, 1955, Idaho Power signed a contract with Morrison-Knudsen for construction of Brownlee and Oxbow. Next day, Brownlee construction got under way.

One of the biggest hydro projects ever undertaken in the Pacific Northwest, the Brownlee project required these major items of work:

1. Construction of the mammoth rockfill embankment, nearly 400 ft. in maximum height, 1,380 ft. in crest length, and containing more than 6,500,000 cu. yd. of material.

2. Driving of nearly a mile of tunnels, including a 2,555-ft.-long diversion tunnel, and four 27-ft.-diameter penstock tunnels, each 550 ft. long.



SINKING DRILL HOLES: An array of different sizes and types of drills was required for the king-sized Brownlee operation. Shown here are Air-Tracs and a truck-mounted Drillmaster sinking holes in the tailrace channel.

3. Excavation of a giant U-shaped cut, 300 ft. deep, for the spectacular concrete spillway.

4. Excavation of cuts for the powerhouse, intake structure, and intake channel.

5. Placement of some 250,000 cu. yd. of concrete for the powerhouse, intake structure, and spillway.

6. Construction of more than 100 miles of roads directly related to the project.

7. Erection of a 600-ft. steel bridge for the Union Pacific Railroad and relocation of 10 miles of main-line track to sidestep Brownlee's 57½-mile-long reservoir.

Brownlee required more drilling and blasting than many another big dam job, with more than 6,000,000 cu. yd. of stubborn rock excavated for the deep foundation of the embankment, powerhouse, tunnels, the yawning spillway and intake cuts, and assorted other phases of the project.

The Brownlee area's rock is hard and durable Columbia River basalt, laid down those countless ages ago in five thick flows of lava. Most of the herculean job of drilling and blasting performed by M-K's dam builders was in the bottom three flows, which are classified as feldspar-porphyritic, columnar jointed, and massive basalt.

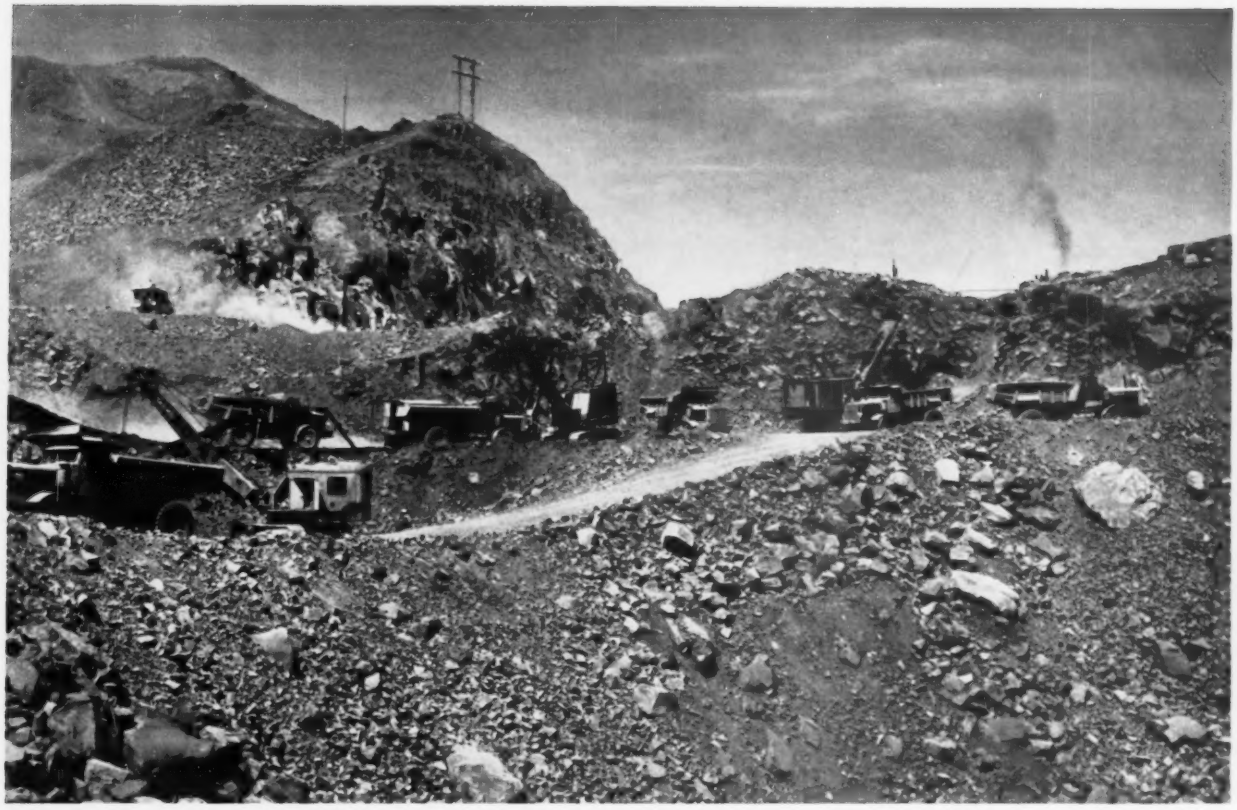
Drilling Equipment at Brownlee

The builders employed an array of nearly 30 drills for the king-sized task. These drills included three Joy TM-500's, two of which were mounted on D8 Cats, and a truck-mounted Ingersol-Rand Drillmaster. The Drillmaster's truck also carried a compressor mounted crosswise on the frame and a collector that reduced the dust nuisance to a minimum. Also part of the rock-biting array were 17 Gardner-Denver Air-Trac drills.

Two custom-built drill jumbos were the headliners of the Brownlee drilling show. One of them, specially built for the job in M-K's Boise headquarters shops, was a huge rig used to drive the mammoth diversion tunnel. Mounted on the chassis of a Euclid end-dump truck, it carried a battery of 14 Joy TM-350 drifters on three platforms. The jumbo was used to drill both the downstream and upstream headings of the bore, shifting from one to the other as it was needed.

A horseshoe-shaped tunnel 38 ft. wide and 42 ft. high, the diversion bore had a capacity of 30,000 c.f.s.—adequate to handle normal flows of the river. It required 110,000 cu. yd. of excavation, with an 80D shovel mucking out the blasted rock and loading it into end-dump trucks equipped with

PACKING THE PUNCH: The blasting crew is loading holes for a blast at the start of a deep U-shaped cut for spillway on the Oregon side of the river. The spillway was worked down in lifts of about 60 ft.



INTAKE AREA: While the drilling crew prepares the holes for another blast on an upper level, shovels and trucks remove blasted rock in the powerhouse intake area on the Idaho side of the project.

"scrubbers" to filter their exhausts. The 80D's regular diesel engine was replaced by an electric power unit for the tunnel-mucking chore. Ventilation problems were whipped by two Joy Axivane blowers installed directly in the duct lines as boosters.

The diversion bore was unlined except for a 50-ft. section at the intake and a 450-ft. section from the powerhouse location toward the mouth. It is planned that this 450-ft. section will be used as a tailrace for an ultimate fifth unit.

Second of the custom jumbos was a two-platform rig used to drill the four penstock tunnels. These 27-ft.-diameter bores were drilled upward at an angle of 16 degrees 42 minutes with the horizontal—a 30% grade.

The big drills in M-K's array chewed into the rock with carbide-insert bits ranging from 2 in. to 6½ in. in diameter. Carbide-insert bits 2¾ in. in diameter were usually employed in the Air-Tracs.

Drilling and Blasting Procedure

Dynamite of several different grades, packed in cartridges ranging from 1½ by 8 in. to 3 by 24 in., was used on the Brownlee project. Driving of the diversion tunnel alone took 155,200 lb. of explosives, including 40 and 45% gelatin and ammonium nitrate types of dynamite.

On the average, 89 holes per round were driven in the diversion tunnel. Average depth of the holes was 13 ft. The 89-hole rounds were loaded with a total of 765 lb. of powder per round.

In the tunnel and elsewhere, excellent break-up generally was obtained, with little reshooting of boulders required. The spillway, powerhouse, and intake cuts were worked down in lifts of about 60 ft., with excavators and trucks rolling in to move the rock soon after each blast.

Providing the prodigious amount of air required by the assorted drills was an equally impressive fleet of compressors. Among these machines were three Ingersoll-Rand XLE 1,352-c.f.m. stationary compressors, six I-R 900-c.f.m. portable rotaries, and eight I-R 600-c.f.m. portable rotaries.

It was normal artesian water found within the lava flows in the embankment core area that led to some of the big project's earliest drilling. First, with the area protected by temporary cofferdams, the dam builders excavated the core area to bedrock—about 115 ft. below the old river bed. Then, to assure a foolproof grouting job, they drilled holes in the core area that varied from 10 to 25 ft. deep and were on 10-ft. centers. These holes were grouted at pressures ranging to 100 p.s.i.

With the core area thus effectively consolidated, cut-off grouting was performed along a line of holes drilled on 10-ft. centers to a depth of 150 ft. Completion of the grouting operations in this area opened the way for placement of the impervious core and filter

zones up to river bottom.

This work was performed during the 1956 low-water season. When the 1957 spring runoff began rolling down the river, the cofferdams were breached and water not accommodated by the diversion tunnel was allowed to pass over the core area. The core was dewatered in July with runoff's end and was found to be in excellent condition. Construction of the embankment was immediately resumed.

The Spillway Cut

Biggest of M-K's rock-excavation tasks was the spillway cut, on the left, or Oregon abutment of the embankment. There, drilling and blasting with production-line precision, its crews moved a total of some 1,187.000 cu. yd. of rock to make room for the big structure. The spillway itself, designed to pass a flood of 300,000 c.f.s., consists of a concrete gravity dam, 168 ft. high, and a concrete chute some 600 ft. long that passes discharged water back into the river downstream from the embankment. Four steel tainter gates—each 50 ft. high and 32 ft. wide—stand on the crest of the concrete dam, with three 23 by 23-ft. steel tainter gates blocking three low-level outlets near its base.

Placement of more than 115,000 cu. yd. of concrete for the heavily reinforced spillway was handled by several cranes and a stiffleg derrick that was anchored on a shelf high above the cut. This derrick, fitted with a boom 207 ft. long, lowered two concrete buckets simultaneously into pouring position, lifting them from a fleet of trucks that hauled the concrete from a mixing plant located nearly a mile away. Once the embankment had been raised to sufficient height, the stiffleg and smaller cranes were joined in the clockwork pouring operatio.. by a Manitowoc 4500 that was walked to the top of a flat-topped island of rock separating the spillway from the embankment.

Another Big Cut

Second biggest of M-K's excavation tasks was the cut for the intake structure and its channel, for which a total of 1,350,000 cu. yd. was hewed with drill steel and powder from a mountainside. One broad bench in the vast excavation, which was started near the top of the mountain, carries a road around the intake and its channel.

HARD ROCK: Most of the rock in the Brownlee area is a hard and durable Columbia River basalt. It was through this type of rock that the approach channel to the diversion tunnel was blasted.

More than 700 ft. long and 160 ft. deep, the channel carries water from the reservoir to the intake. It is a 168-ft.-high concrete structure that regulates the flow of water into the penstocks by means of four gates, each 16 ft. wide, 30 ft. high, and operated by a 100-ton electric hoist.

Because the tremendous quantity of rock to be excavated from the intake channel meant it would be one of the last phases of work finished, M-K and Idaho Power supervisors decided on an unusual scheme to speed completion of Brownlee's power-producing facilities. The scheme: drive the penstock tunnels from the bottom—or powerhouse end—up, instead of from the top—or intake end—down. Such a procedure would permit the fast-working dam builders to complete the penstock tunnels and powerhouse while the intake-channel excavation was under way. To wait until the channel had been excavated before starting the penstock tunnels clearly would mean a delay of as much as a year in completing the project and getting its power "on the line."

Excavation of the powerhouse area was the first step in putting the novel scheme into motion. The mammoth cut was rapidly drilled and blasted in a series of lifts down to the elevation of the penstock tunnels. Then, while work on the powerhouse itself was slacked off to give the tunnel driving clear right-of-way, M-K underground crews moved in to thrust the 550-ft.-long penstock bores upward on the designed 30% grade through the mountain's rocky heart toward the future intake.

Some 435,000 cu. yd. of rock were drilled and blasted from the big powerhouse cut, while about 50,000 cu. yd. were shot and mucked from the penstock tunnels. Most of the rock was removed from the tunnels by overhead loaders, which lifted the material into trucks after it had been pushed toward the mouths of the bores by Cats working on the steep grades.

The custom-built jumbo used to drive the 27-ft.-diameter penstock tunnels was mounted on an International TD-14 tractor. On level ground, its two drill platforms were inclined; but when at work in the slanting bores, the platforms were level.

DIVERSION TUNNEL: The workman in the mouth of the diversion tunnel indicates the size of the mammoth bore that carried the Snake River around the embankment area in the early stages of the project.

Installation of Penstock Liners

Once the tunnels had been thrust as far as possible through the rock, and a connecting gallery had been carved at their upper ends, another unusual operation was launched to install the 24-ft.-diameter steel penstock liners themselves.

In another foresighted move to speed Brownlee's completion, prefabrication of the liners had been started long before the tunnels were finished.

The massive liners were prefabricated in 60-ft. sections in a yard located just downstream from the powerhouse area. Basic units for the sections were plates 7½ ft. wide and ranging in thickness from ¾ to 15/16 in. To begin the prefabrication of each section, three of these plates were lifted by a Manitowoc 4500 onto a template to form a 7½-ft.-high cylinder known as a "can." The can was meticulously trued, the pieces were tackwelded together and then the internal bracing spider was installed.

Next the can was transferred to the yard's welding house, where Lincoln automatic welding machines put the finishing touches on the tube. The machines made longitudinal welds between the can's three pieces, performing the job in one pass inside and one outside.

As the cans were completed, they were moved from the welding house to special Worthington power-driven roller beds nearby for assembly into

PENSTOCK TUNNEL: Air-Tracs are shown at work in one of the four penstock tunnels. These 27-ft.-diameter tunnels, each 550 ft. long, were driven from the downstream end on a 30% grade. A small jumbo with a two-platform rig was also used.

the 60-ft. sections. On the roller beds, two cans first were butted together. Then, with the rollers slowly rotating the tubes, a Lincoln automatic welding machine mounted at the top of the joint fused the two cans in a single operation. Eight cans were joined by this method to form each 60-ft. section. The man-dwarfing sections ranged in weight from 65 to 95 tons, depending on wall thickness.

To install the sections, M-K's men moved them to the mouths of the penstock tunnels on Forged-Trak trailers drawn by tractors. A 10-part cable was secured to each section and it was pulled up the 30% grades into place by a Lidgerwood two-drum hoist at the top of the tunnels. During the trip, the sections rested on wheeled cradles that rode rails set atop concrete blocks on either side of the inverts.

Sections were joined in the tunnels by Lincoln automatic welding machines mounted on frameworks that almost completely encircled the steel tubes. After they were welded, the liners were securely anchored to the footing blocks. As the final step in the liner installation, the tubes were encased in concrete forced between them and the surrounding tunnel rock.

Concrete was being poured for Brownlee's powerhouse even as the last of the penstocks were being completed. To get the block-long structure under way as soon as possible, pouring began at one end of the deep powerhouse cut while the penstock work continued at the other.

A Man-Made Mountain

Clay for the embankment's impervious core was hauled from mountainside borrow areas as far as 3 miles away. But much of the rock for the man-made mountain came from the project's king-sized cuts: spillway, intake, and powerhouse. Teamed in the grueling rounds of load, haul, and dump . . . load, haul, and dump—from clay borrow areas and from rock cuts—was an awe-inspiring array of excavators and trucks. They were the nucleus of a fleet of machines of all types whose value hit more than $7,000,000 at the peak of the fast-paced project.

Excavators at Brownlee totaled 22, including four Bucyrus-Erie 54B shovels, two Manitowoc 4500's, two Bucyrus-Erie 88B's, four Bucyrus-Erie 71B's, and a Northwest 25. M-K threw as many as 42 Euclid end-dump trucks of 17-yd. capacity into the big material-moving operation, along with 14 Euclid bottom dumps of 17-yd. capacity. Three Euclid Rock Wagons joined these fast-rolling rigs for the later stages of the job. Also in M-K's stable of modern machines were about 30 tractors, 10 Dodge Power Wagons, 26 flatbed trucks of various makes, two Euclid 25FDT water tank trucks of 5,000-gal. capacity, and even a tugboat used during installation of the downstream-migrant fish facility.

Precise planning, coupled with preventive maintenance of equipment, enabled M-K's dam builders to move more than 20,000 cu. yd. of rock in a single day. In a six-day week, production hit as much as 120,000 cu. yd.

Brownlee's sloping impervious core ranges in thickness from about 50 ft. at the bottom to 12 ft. at the top. Its material is a residual basaltic soil of medium plasticity, with a natural water content varying between 15 and 30%. After it was placed by M-K's bottom dumps, the clay was spread in 8-in. layers compacted by specially built rollers to 90% of modified A.S.S.H.O.

Two filter zones—one fine, the other coarse—and a selected rock zone prevent the core material from migrating into the downstream rockfill's voids. Similar filters, arranged in the opposite direction, prevent migration into the upstream fill.

Every step known to modern con-

struction was employed to minimize settlement of the embankment. One of them was heavy sluicing of the rock fills, starting as the rock was placed by the end-dump trucks to wash the fines into the voids and obtain maximum point-to-point contact of the rock. The sluicing was performed by three Stang Intelli-Giant hydraulic monitors mounted on skids. Equipped with 2- and 3-in. nozzles, they sluiced the fills with about four times as much water as the total volume of rock that went into the embankment.

May, 1958, saw Brownlee turn into the homestretch. In that month, water began to fill the reservoir as gates were dropped to block the diversion tunnel. Four days later, water was discharged for the first time through the spillway's low-level gate openings.

And then came August 27, 1958. On that memorable day, power flowed from the first of Brownlee's four initial generating units as President T. E. Roach of Idaho Power turned a switch to put it into production.

Just as notable was the following October. The huge embankment was "topped-out" as trucks dumped the last of its material in place. Workmen finished installing the spillway's four steel crest gates and put the finishing touches on the intake. Upstream, the costly and unique downstream-migrant fish facility went into operation.

And, in October, the second unit went "on the line." It was followed in December by the third unit and in January, 1959, by the fourth unit.

Brownlee's Supervising Personnel

Brownlee's high-speed construction was supervised for M-K by two of its veteran dam builders: Glenn C. Johnson bossed the big and varied project during its early stages and was succeeded later by Simon Piedmont. Overall supervision was exercised by the late B. "Woody" Williams, M-K vice president, until his death, and then by G. M. Shupe, M-K dam division manager, to its finish.

Until their deaths during the project, overall responsibility for Idaho Power was held first by E. A. Woodhead and then by Fred R. McCormick, both functioning under R. E. Gale, vice president of operations and construction for the utility. Gomer Condit was Idaho Power's resident engineer.

JUMBO: This jumbo, custom built in M-K's headquarters shop, was mounted on a Euclid end-dump truck chassis. It was equipped with 14 drills located on three decks and beneath the bottom deck.

A Longer Deep-Water Channel For the Delaware River

When the new 40-ft.-deep channel is completed, an entire new area along the Delaware River will be available to industry

EVERETT F. DIEHL*

EVER since Colonial times the Delaware River has been one of the main arteries of commerce on the Eastern seaboard. Among the many industrially important cities located on this vast waterway, whose source is in upper New York State, are Wilmington, Delaware; Chester and Philadelphia, Pennsylvania; and Camden and Trenton, New Jersey. Many of the varied products manufactured in this area are shipped via the Delaware River to all parts of the world.

A 40-ft.-deep channel, suitable for the largest ocean-going vessels, makes the Delaware an excellent shipping facility for industries located in Philadelphia and to the south. However, the river north of Philadelphia is quite shallow and navigable only to vessels of comparatively shallow draft. With a deep-water channel only to the

*Hercules Powder Company
New York City, N. Y.

WORLD COMMERCE: When the lengthening of the Delaware River channel between Philadelphia, Pennsylvania, and Trenton, New Jersey, is completed, industries between these points will be able to ship their products to all ports of the world by ocean-going vessels.

Philadelphia-Camden area, the harbor areas of the Delaware have almost reached a saturation point, with industrial plants crowding each shore line.

To relieve this congestion, the U. S. Army Corps of Engineers is engaged in a program to open the area above Philadelphia to further industrialization by providing a deep-draft waterway for large seagoing cargo vessels. This will undoubtedly encourage industry to obtain factory sites that are now beyond the navigable channel. The proposed channel will be 400 ft. wide with a depth of 40 ft. at mean low water, and will extend from Philadelphia to Trenton.

Exploratory Probing

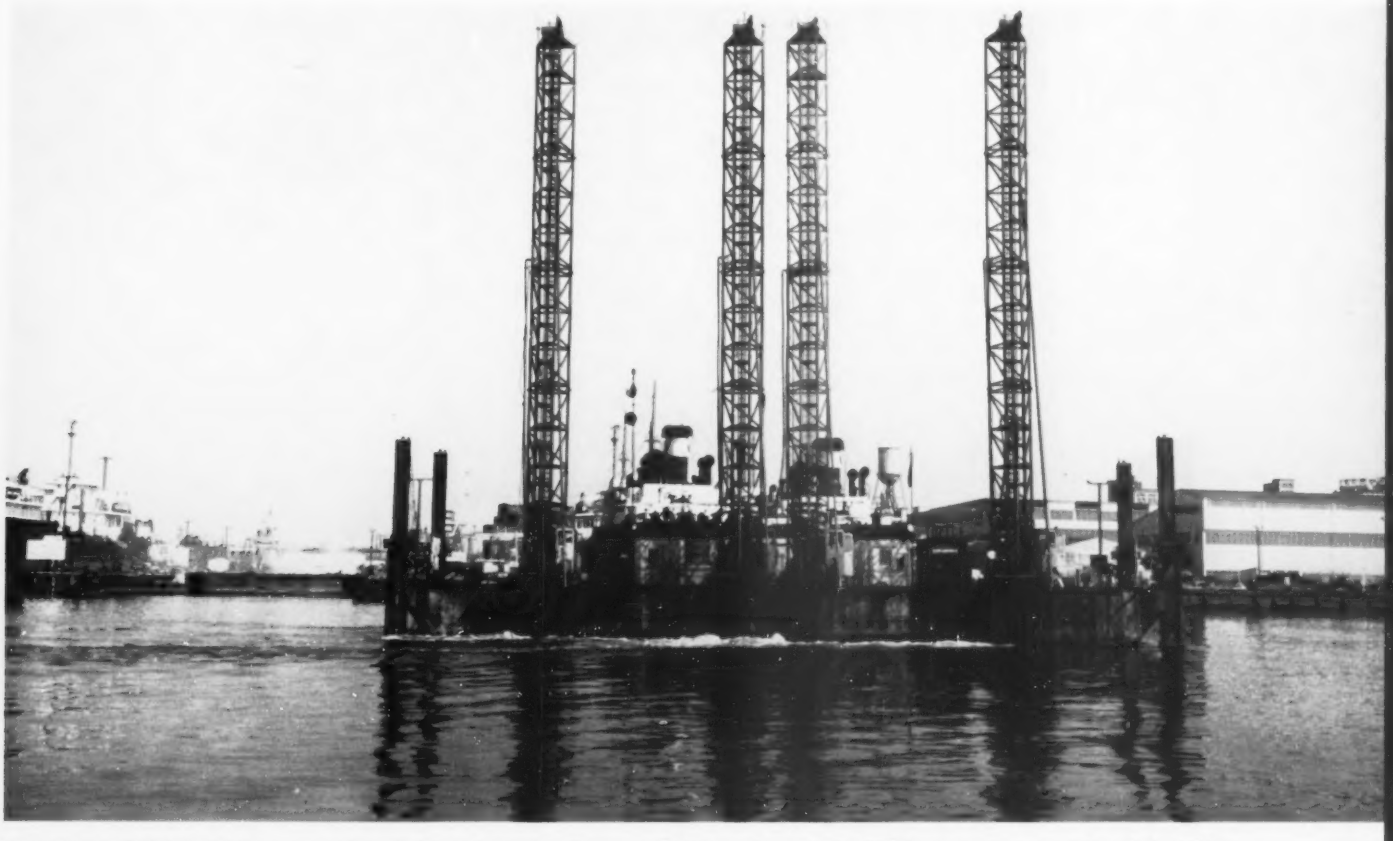
Exploratory work to determine the character and profile of the river bottom for bidding and specification purposes was determined by the use of jet probers mounted on a specially constructed barge. This 100-ft.-long and 30-ft.-wide barge, designed by the Philadelphia District Corps of Engineers to speed up the probing, mounted six probing towers, three on each side, each 37 ft. high. The towers were mounted on rails running the length of each side of the barge deck. The probes consist of a 2-in.-diameter pipe with a jet nozzle at the tip. Each tower has its own air-powered motor for raising and lowering the probe. With this setup it was possible to explore the bottom of the proposed channel with maximum efficiency, both from a time and labor standpoint.

When the jet-probe barge was in position, it was anchored by two 70-ft. spuds, each weighing about 17,000 lb.

First Rock Contract

The first rock contract for deepening the channel was awarded by the Corps of Engineers to the American Dredging Company of Philadelphia. The contract comprised an area known as Section R-1B—Mud Island Range, and called for a channel 400 ft. wide by 40 ft. deep and 2,000 ft. long, requiring the removal of 217,600 cu. yd. of unclassified excavation consisting of overburden and rock. This area, adjacent to Riverside, New Jersey, and to Torresdale, Pennsylvania, is about 4½ miles upstream from the Tacony-Palmyra Bridge.

The American Dredging Company started its drilling and blasting operations on November 26, 1958. Its drill boat is completely modern in design and equipment. It mounts four Model 325-A Ingersoll-Rand Down-Hole drills, each powered by its own 500-cu. ft. Gyro-Flo Ingersoll-Rand compressor. The drill boat is equipped with a machine shop for the maintenance of the drills and compressors and is so completely equipped that almost any



THE DRILL BARGE: Of the most modern design and carrying the most efficient equipment, the drill barge works around the clock sinking drill holes for the explosives charges.

TRANSFERRING EXPLOSIVES: Because of the regulations limiting the quantity of explosives stored on the drill barge, the diesel-powered work boat must make several trips a day to keep the loading crews supplied with explosives.

repair work to the equipment can be done without the necessity of taking the drill barge out of service.

The magazine for the storage of explosives, and a separate blasting cap magazine, both maintained under strict supervision, are located on the barge. Only a limited quantity of explosives, just sufficient for current operations, is stored on the drill barge.

Some preliminary work was done on the job site on a previous contract. This work consisted of the removal of practically all the overburden material by hydraulic dredge. Subsequent test borings revealed that the material yet to be removed from the new channel consisted of highly weathered to firm mica schist, biotite schist, and gneiss interspersed with traces of quartz.

Drill Pattern

The drill pattern is 10 by 10 ft., and each range will consist of 10 holes, each 6 in. in diameter. An average of 8 ft. of subdrilling will be maintained throughout the job, taking the holes down to 48 ft. below low water. The actual amount of drilling will depend upon the contour of the river bed and will vary from 8 to 24 ft. of rock.

The drill barge is sighted in on the range by the barge foreman, and when lined up with the range markers on the shore, the spuds, one at each corner of the barge, are lowered to the bottom of the river to make the barge a steady platform for drilling operations. An 8-in. sandpipe is then lowered to the bottom of the river and drilling proceeds through the sandpipe casing. Ingersoll-Rand 5-in. drill steel with Ingersoll-Rand and Brunner & Lay 6-in. insert bits is used to sink the holes. It is estimated that about 80 ft. of drill hole can be made before a change of bit is necessary.

Explosives Regulations

All explosives operations, because they take place on a navigable waterway, are subject to the rules and regulations of the United States Coast Guard. The well-constructed explosives storage magazine, which has a capacity of 20,000 lb., is located at an isolated spot inland from the river. Explosives are transported from the magazine by truck to a small diesel-powered launch which, under Coast Guard regulations, is permitted to carry only 3,500 lb. of explosives per trip. Depending on the progress made

at the drilling site, the work boat will make several explosives-carrying trips a day. This boat also serves to transport the workers and barge crew for each shift.

Loading Procedure

After a hole is drilled to the necessary depth, the drill is run up and down several times to make sure the hole contains no obstructions. Then the drill is removed and replaced with a 5-in.-diameter tube through which the dynamite is loaded.

The loading crew, working from a platform that is part of the drilling rig, inserts the first cartridge, which is primed with a Short-Period Delay Electric Blasting Cap into the loading tube; and it is then lowered in the tube to the bottom of the hole. The balance of the cartridges is loaded through the loading tube and a tamping rod is inserted in the tube and held against the explosives as the tube is withdrawn. The explosives used is Hercules® 60% High-Pressure Gelatin in 4 by 12-in. cartridges. This dynamite is a modified gelatin type and will propagate and detonate under greater water pressures than corresponding grades of regular gelatin dynamites.

The quantity of dynamite loaded in each hole varied, depending upon the depth of the rock. However, to keep noise and vibration to a minimum no more than 800 lb. is ever detonated at one time. The average loading factor is 1½ lb. of explosive per cu. yd. of rock.

The 10 holes are primed with Hercules® Short-Period Delay Electric Blasting Caps using instantaneous to No. 9 delay periods connected in parallel. No stemming operation is necessary because some overburden will fall into the hole as the loading tube is withdrawn. This overburden, plus the water in the drill hole, makes a very satisfactory confining material.

When all the holes are loaded, the spuds are raised, and the drill barge is pulled away from the range. The blasting foreman plays out the lead wires that are connected to a safety switch on the drill barge's lighting system. When the barge is in a safe position, about 300 ft. from the loaded

LOADING THE HOLES: Holes are loaded with 60% High-Pressure Gelatin primed with Short-Period Delay Electric Blasting Caps, instantaneous to No. 9 period, connected in parallel. This type of dynamite is used because of its ability to detonate under high water pressures. The amount of dynamite varied with the depth of the rock.

SEISMOGRAPH STATION: The Leet seismographs located on each side of the river record the intensity of each blast on both the New Jersey and Pennsylvania shores.

range, the blast is fired. To move the barge, to fire the blast, and to set up on the new range location requires about 30 minutes' time.

Rock Removal

A new dipper dredge of latest design, built by the Ellicott Machine Corporation of Baltimore, Maryland, follows the drill barge to remove the blasted rock from the channel. A 6-cu. yd.-capacity dipper scoops up the rock and dumps it into scows which are towed to a disposal area some distance down the river.

Seismograph Recordings

An unusual feature of this project is that the contract specifies that seismograph records of every blast must be made from both the New Jersey and Pennsylvania shores. According to the specifications, the energy ratio as determined by the seismograph readings cannot exceed 1.0. The extremely low powder ratio of 1½ lb. of dynamite to a cu. yd. of rock, plus the use of Short-Period Delay Electric Blasting Caps in each drill hole, assures a minimum of vibrations from blasting operations.

CONTROLLED BLASTING: Little more than a ripple is made on the surface of the river as a range of 10 holes is detonated. Carefully calculated explosives charges and the use of Short-Period Delay Electric Blasting Caps have kept the vibration ratio well within the limits set by the U. S. Army Corps of Engineers' specifications.

ROCK REMOVAL: The new dipper dredge, "The President," with a 6-cu. yd. bucket easily transfers the blasted rock from the channel to awaiting scows. The loaded scows are towed to a disposal area down the river.

The seismographs used will measure the vibrations transmitted to each shore to make positive that the explosives factor is kept well within specified tolerances. This precautionary measure helps avoid any damage from vibrations to houses or other structures along the waterfront.

All phases of the blasting operations are carefully controlled to avoid excess vibrations and noise; in fact, the operation has been noted for the absence of fly rock.

Key Personnel

Col. William F. Powers directed the Delaware River Project for the U. S. Army Corps of Engineers prior to July 1, 1959. On that date Col. Powers was relieved by Col. T. H. Setliffe, who is now district engineer for the Philadelphia District and in charge of this project for the Government.

Maylin H. Greaser, president of American Dredging Company, has assigned the responsibility of the project to Paul MacMurray, vice president of the dredging company. Stewart M. Riedinger is superintendent of operations. Joseph Murdock is drill boat superintendent, and the drill boat captain is William Kimmitt.

SIGHTING THE RANGE: The drill barge foreman sighting in on the longitudinal and side ranges used to accurately locate the drill barge.

Quarrying A Hard Kansas Limestone

Quartzite Stone Company has found use for unusual stone heavily interspersed with loose sand

FARRELL CASTELLANI*

LINCOLN COUNTY in north central Kansas is the site of a curious formation of stone quarried commercially by the Quartzite Stone Company. The stone varies in thickness, and it usually rests on a loose sand floor. It is extremely hard, and occasionally is heavily interspersed with loosely packed sand pockets.

*Hercules Powder Company
Joplin, Missouri

Limestone suitable for concrete aggregate is scarce in western Kansas, making this Lincoln County quarry probably the nearest location for good stone. The material is a siliceous and calcareous rock chemically consisting of 68% silicon dioxide, 16% calcium oxide, 13% carbon dioxide, and the balance of 3% consists of aluminum, ferric, magnesium, sodium, and potassium oxides.

In 1931 the Lincoln Stone Company operated at the present site. At that time A. A. Wilson of Concordia, Kansas, who held a mortgage for $25,000, was suddenly called and told he had a plant. He sent his son-in-law, J. R. Carlgren, to protect the investment, and their net valuation figures on that date and today attest to the measure of success obtained in the 28 years of operation. Mr. Carlgren worked in a

SHOVEL LOADING BROKEN ROCK: Cliff Hall, shooter foreman, stands beside a 1½-cu. yd. Northwest shovel and an International truck which hauls stone from the quarry.

STRIPPED AREA: A view of the quarry floor from which stone has been removed.

bank at Concordia and was quite unfamiliar with stone production, but he went into this job with enthusiasm, and under his direction the company has expanded its sales remarkably. When the plant was taken over, equipment was valued at about $15,000 as most of the work was performed by hand labor. Net valuation of Quartzite Stone today is placed at $1,425,000.

New Uses for Products

The present operators have been successful largely because they have found uses for the sandy material which must be screened out, and for the fines which normal limestone production can sell as fertilizer, but which here were just a waste product.

Quartzite Stone in 1933 started a concrete pipe plant when Mr. Carlgren, for $682.23, bought one-half interest in the company then owned by Mr. Dehner of Lincoln, Kansas. This plant uses all fine aggregate from ¼ in. down in concrete pipe manufacture and makes pipe in sizes from 6 to 84 in. in diameter. Today this business is larger than the concrete aggregate production of Quartzite Stone Company. The fine aggregate also is used in making concrete blocks of all sizes, and a concrete brick is manufactured, which finds extensive use for building in this area. The stone company recently started a ready-mix plant in Lincoln and Concordia, and the Quartzite Products Company, a subsidiary of the Quartzite Stone Company, has just opened a corrugated pipe plant at Concordia, Kansas, to implement its concrete pipe manufacturing and servicing facilities.

The Quartzite Stone Company formation has a variable amount of overburden, which is handled by 2-D7 Caterpillar dozers and a 6-cu. yd. LeTourneau scraper. The formation itself varies in thickness from 8 to 45 ft., and the percentage of loose sand in the formation also varies greatly. The material over the stone is loosely compacted sandstone and can be handled nicely with the dozers and scrapers. The drilling of the main ledge is done with an Ingersoll-Rand IR crawler, with a D45 drill, and a 4½-in. bore powered by a 1-600 Gardner Denver and a Joy TM 400 with a 4-in. bore powered by a 1-315 Ingersoll-Rand compressor.

Drilling Procedure

For jackhammer drilling, the quarry uses an Ingersoll-Rand 315 and S45 Jackhamer. Sectional steel and carbon steel bits are used in drilling. The throw-away bits used until recently would drill about 6 ft. before being taken out for resharpening, an operation which could be performed only four times before the bit lost its gauge. The carbon steel bits, however, average 1,800 ft. per bit.

Size of holes drilled is 2½-in. diameter spaced on an 8 by 6-ft. pattern. Gelamite® 2, 2 by 8-in. size, is used, and all powder is tamped tightly in the hole to utilize all of the hole

drilled. As the top of the holes is sometimes very ragged, a 3-ft. copper tube 2¾ in. in diameter with a 4-in. flange is placed in the hole, and many a rough hole is easily handled with the loading tube. The loose sand inherent in the formation itself varies greatly, and in any one shot as much as 25% of the material may be loose sand. When this is localized and heavy, a D4 Cat 1½-cu. yd. front-end loader moves this into trucks to go to the grizzly material storage area.

Yield 1.3 Tons Per Pound

The yield per pound of dynamite also varies with the percentage of rejects, but the long-time average is about 1.3 tons pay material per pound of dynamite. MS delays are used in the shot, the number varying with the number of rows and holes shot. From 200 to 470 holes are fired with a condenser blaster, and up to nine electric MS delays are used. Delays are used from row to row. Pop shooting of boulders is done with fuse and caps. Fragmentation is very good.

Two separate faces are worked simultaneously and two Northwest shovels, 1½-cu. yd. capacity, do the bulk of the loading. Five International trucks hauling 8 to 10-ton loads haul from the quarry to the plant.

Quartzite Stone has two preparation plants that are practically twins; and, when business warrants, operates both plants, but always has one plant in operation. These plants are about one mile apart.

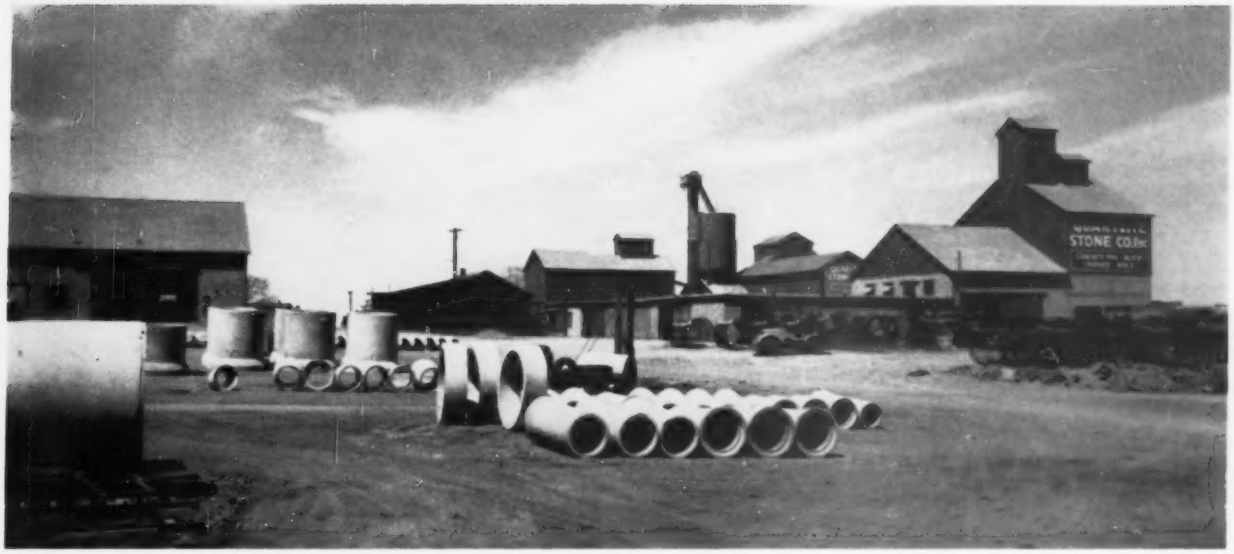
The plants are all electric, and a notable feature is the use of a Jeffrey vibrating feeder consisting of eight electric coils assembled against the feeder chute, which give a pulsating action to the chute and material that falls from there to a feeder pan and to a 4-in. grizzly. Ship anchor chains are suspended onto the feeder pan to facilitate feed control and the whole operation is button-controlled. The feed pan is 5 ft. long and 4½ ft. wide.

Material going beyond the grizzly is fed to a 24 by 36-in. Diamond jaw crusher, 125 hp. and 2,300 volts. The material is so hard and so abrasive that new plates are required on the jaw crusher every 60 days.

All grizzly material 4 in. minus is conveyed to an Allis-Chalmers 5 by 10 screen and all material ¾ in. down went to the waste area until recently. The Kansas Highway Department in recent years has found this to be a good road-base material, so that this former waste material is being used in increasing quantity each year.

All stone over ¾ in. is conveyed to two Symons cone crushers, No. 4 and No. 3, powered by 125- and 75-hp. motors, respectively, at 2,300 volts. Material retained on 2½-in. screen goes through the large-cone crusher and material that passed through the 2½-screen goes through the small cone.

PREPARATION PLANT: One of the two identical preparation plants. It is all-electric and is equipped with a Jeffrey vibrating feeder.



PIPE PLANT: Quartzite's concrete pipe, block, and brick plants, and the plant office.

From here the stone goes to the top screen which is a Deister 5 by 12-in. three-deck screen operated by a 15-hp. motor at 220 volts. Oversize, if any, goes back to the cone crushers. The rock from the three-deck Deister screen goes to three bins. Various sizes of rock, from 4½ to ¾ in., can be produced here. The quarry has three steel bins, one of 50-ton capacity and two of 35 tons each. The company consumes all fine material of ¼ in. minus in its own operation in the making of concrete pipe, blocks, and brick and also in the making of prefabricated concrete bridges for secondary roads.

The constant search for new uses for the stone and sand produced at the Quartzite Stone Company has enabled it to stay in business and serve a large area for a needed basic material. Located on the Sante Fe and Union Pacific railroads, the quarry sells a substantial amount of rock ballast each year for railroad use and also maintains a large fleet of trucks to service pipe, block, brick, and ready-mix concrete customers.

Used As Filter Rock

The hard rock makes excellent filter rock material and is in such demand that it is shipped within a 300-mile radius of Lincoln. The rock produced here has less than 170 absorption on the 10920-cycyle sodium sulfate test.

A 3½ by 10-in. two-deck scalper screen is used over the two Symons cone crushers. Large trucks haul the material from the two plants to the railroad loading area approximately two and three miles away. Fifteen-ton loads are hauled from the plants. Loading ramps facilitate the loading of railroad cars, and Hough loaders load from the storage area to railroad cars whenever necessary.

Production from each of the plants is rated at 1,050 tons of material per day exclusive of fines and grizzly material.

J. R. Carlgren is president of Quartzite Stone Company, Incorporated; E. E. Forney is the manufacturing superintendent; Ray Holman is the quarry plant foreman; and Clifford Hall is quarry superintendent. Rex W. Ryan and Earl P. Liggitt handle the office work.

SALES-MINDED PRESIDENT: J. R. Carlgren, president of Quartzite Stone Company, follows the policy on the wall behind him: "The sales department is not the whole company, but the whole company is the sales department!"

Underwater Forming Of Metals

The aircraft industry finds explosives a quick and economical method of forming some metals into complex shapes

THOMAS A. DICKINSON*

By detonating explosives immersed in water, engineers have been obtaining unprecedentedly good results in forming some of the tougher sheet metals with low-cost tooling at a large aircraft plant in Texas.

The process is based on information acquired by naval experts during World War II as the result of explosions of mines and torpedoes near the metal hulls of ships. Among other things, this information showed that metal parts were sometimes deformed well beyond their normally maximum elongation points without being ruptured, and that extremely tough alloys were sometimes shaped around or over much softer materials.

Efforts to make use of such phenomena have been made by a number of firms, but most of them have involved the transmission of explosive forces with gaseous media alone in enclosed molds or dies.

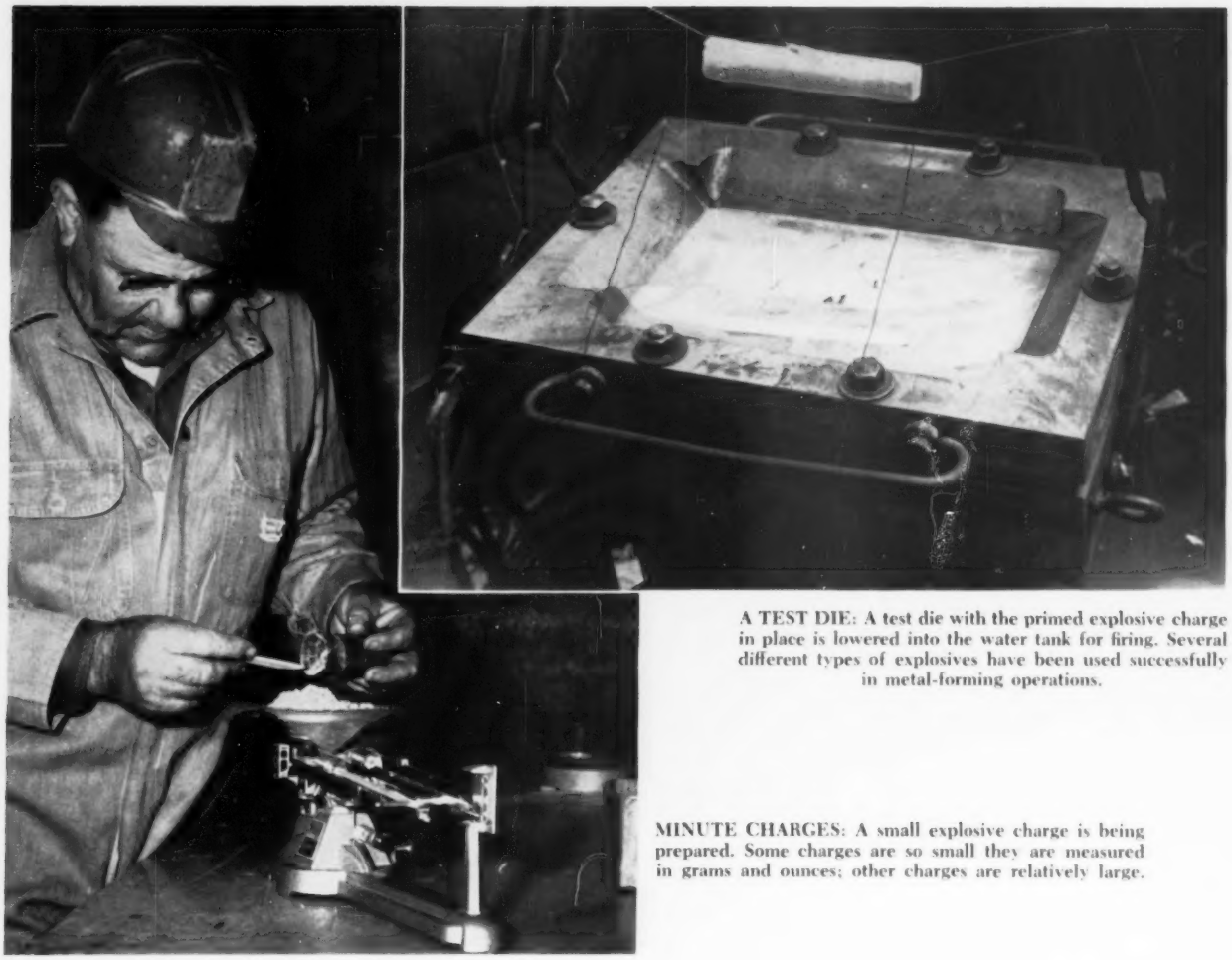
By using water to concentrate shock waves, engineers have been able to make effective use of relatively large explosive charges, including dynamite and gelatins as well as the smokeless powders employed by others, without creating as much noise as could be expected in operating a drop hammer.

The Process

Briefly the process consists of placing a metal blank over a die or basic work form in the bottom of a water-filled retainer, and then setting off a charge of explosives in the water directly above the blank.

*Box 32067, El Sereno Station
Los Angeles 32, California

SMALL GEYSER: As the metal-forming explosive charge is detonated, a small geyser rises from the water tank. The flag waving from the pole serves as a warning signal that blasting activities are under way—just one of the many safety precautions taken.



A TEST DIE: A test die with the primed explosive charge in place is lowered into the water tank for firing. Several different types of explosives have been used successfully in metal-forming operations.

MINUTE CHARGES: A small explosive charge is being prepared. Some charges are so small they are measured in grams and ounces; other charges are relatively large.

According to one of the research engineers, the new process has been used to duplicate virtually every operation that can be performed with drop hammers, hydraulic presses, press brakes, and stretch tooling—including shrinking, bending, shearing, piercing, stretching, embossing, inlaying, and joining.

Complete cost comparisons have not yet been made. However, it has been noted that where either submerged explosives or standard machine tools might be used to produce a given part with identical dies, conventional presswork is usually most economical.

Therefore, it seems reasonable to assume that this method of forming metal will be most advantageous where it will permit the use of relatively inexpensive or simplified tooling, reduce the number of operations essential to orthodox fabrication, minimize scrap, or eliminate the need for additional press capacity.

The potential usefulness of the process in fabricating extremely large parts is especially intriguing, for, as a research engineer points out:

"We could probably use the entire Gulf of Mexico as a shooting basin and produce a deep draw big enough to house a large city if we wanted to develop a blank, forming tool, and explosive charge of such tremendous proportions."

As yet, nothing that awe-inspiring is being seriously contemplated. However, we believe this method will bring aircraft and missile production extremely close to the ideal state, that is, where each new product can be "made in two pieces and glued down the middle."

Materials that have been successfully formed include all common aluminum and magnesium alloys, 17-7 and other stainless steels, 4130 steel, mild steel, titanium, copper, and lead in gauges ranging from 0.0015 to 0.500 in.

Forming tools used in connection with the process have been satisfactorily made from such various materials as tool steels, mild steel, aluminum-zinc alloys, lead, lead-bismuth alloys, plastics, ceramics, and waterproofed paper. In addition, some cuplike parts have been formed without special dies.

To date, the process has been used only by highly skilled technicians working in a restricted area where strict safety practices can be maintained. As a result of the precautions taken, there have been no accidents, near-accidents, or misfires.

Lake Mead

CHARLES F. THOMAS°

A gem, set deep mid serrate, high-crowned hills,
Reflecting through the passing hours of day
A thousand changing hues with countless thrills
To greet the eye with sparkling, crystal ray.

No talisman, no pearl, no jewel bright
Can cast such spells nor myriad moods reveal
As from those mirrored depths comes living light,
And wind-etched facets hidden gleams unseal.

The morning sun swings from the East, ablaze,
And with the crimson dawn a garnet rare
Shines from the tinted mountains' circling maze,
To double nature's glory painted there.

When from the heavens high, at noon, hot rays
Burn down on wav'ring peaks; dull, dim, and drear,
A smoky topaz there encrusted lays
In strata gray, unpolished, like a tear.

Through swiftly winging hours to eventide
The far sun rolls into the rose-hued West;
A turquoise blue, deep shaded, sets inside
The matrix of the painted hills' rough crest.

From far worlds night chips flintlike stars to spill
And gently light the gloom. A darkened shade
Is drawn and hides deep canyon, lake, and hill—
The crystal waters turn to ebon jade.

°Palmdale, California

NEWS NOTES

TRUCK EQUIPMENT CATALOG

Single, and tandem axle; light-, medium-, and heavy-duty contractor-type dump bodies; dump trailer units; and hydraulic hoists—all of which embody new design and construction features—are among the products displayed in a colorful new equipment catalog just released by Hercules Steel Products Company, Galion, Ohio.

Highlighted are dump-body and hoist specifications, exclusive design and construction features, special truck equipment—including hydraulic tail gates, and a new series of engineering charts designed to aid dump body and hoist selection. Free copies of the catalog are available on request.

GOGGLE-CLEANING STATION

To promote prompter, easier care of industrial eye-protection equipment, Mine Safety Appliances Company, Pittsburgh, Pa., has made available a new goggle-cleaning station with fingertip convenience.

Feature of the new low-cost station is a compact all-metal cabinet having a capacity of 200 sheets and provides a fresh tissue each time one is removed. Cabinet measures 6 in. high, 5¼ in. wide, and 6 in. deep. Lens-cleaning Fogpruf fluid is dispensed in exact amount from unbreakable, leakproof, polyethylene squeeze bottle, which can be used separately in locations that do not warrant cabinet installations. A cleaning and anti-fogging agent of fluid removes dirt and grime without streaking, and coats lens surface with micro-thin film that protects against fogging for hours after application, according to the manufacturer.

MULTIPURPOSE LUBRICANT

Keystone Lubricating Company announces the development of premium-quality multipurpose lubricant for industrial use.

Known as Keystone No. 88 multipurpose lubricant, this product has application in 90% of all ball- and roller-bearing installations. It also produces superior results in plain bearings, needle bearings, and on rotating and sliding surfaces, according to the manufacturer.

A high-film-strength, lithium-base product with excellent water-repellent properties, Keystone No. 88 is unaffected by exposure to damp atmosphere or direct contact with water and has powerful absorptive properties. It is smooth, nonfibrous, homogeneous, and odorless. Operating temperatures range from 0 to 275°F., and the melting point is close to 400°F.

Additional information on Keystone No. 88 multipurpose lubricant is available from Keystone Lubricating Company, 3100 North 21st Street, Philadelphia 32, Pa.

FIRE HYDRANT CIRCULAR

An 8-page bulletin describing a new line of fire hydrants manufactured by Kennedy Valve Manufacturing Company, Elmira, N.Y., has just been completed and is now ready for distribution.

The new fire hydrants, named the K-10 and the K-11, are completely redesigned and have a minimum number of parts. The manufacturer claims that all working parts can now be easily removed for maintenance without excavation. Both hydrants feature "O" ring construction.

The K-10 is the regular-model hydrant with bolted joint construction while the K-11 is the new, improved Safetop model. Both conform to all A.W.W.A. specifications and are manufactured in 4, 4½, and 5 in. with a wide variety of pipe end connections to meet every need. For a copy of the descriptive literature, write for Bulletin 591.

MODIFIED COMPRESSOR

A modified version of the 125-ft. rotary power take-off compressor is announced by Worthington Corporation's Holyoke (Mass.) Division.

The basic compressor system is similar to the Worthington 125-ft. rotary power take-off unit; however, it includes a chain drive and clutch.

The unit includes a two-stage oil-cooled rotary compressor, speed control, engine governor, oil cooler, air receiver, oil separator and oil storage receiver, all mounted on a common base plate.

Completely controlled from the cab by the driver, the compressor is belt-driven through a split power take-off.

Additional information may be obtained by writing Worthington Corporation, Portable Compressor Section, Holyoke, Mass.

PORTABLE BATCHING PLANT

An easily transported, rapidly assembled concrete batching plant that produces up to 60 cu. yd. per hour for scattered, small-scale building operations is now available. According to the manufacturer, the unit has storage capacity for 40 tons of aggregate in three sizes and 950 cu. ft. of bulk cement. Additional information may be obtained from The Noble Company, 1860 Seventh Street, Oakland, Calif.

CRANE-EXCAVATOR BULLETIN

Schield Bantam Company of Waverly, Iowa, has announced the publication of an 8-page specification bulletin covering the new series "350" BANTAM crane-excavators.

Included in the new bulletin are complete specifications, capacities, work ranges, and features on the 11-ton carrier-mounted Model T-350, the 11-ton self-propelled Model CR-350, and the Model C-350 crawler-mounted Bantam, as well as the complete line of attachments. Specifications on all mountings are also given.

Copies of the new specification bulletin, No. 350-1, are available from the manufacturer.

NEW JOY SLUSHER BULLETIN

Joy medium-capacity, 15 to 40-hp. slushers are the subject of a new bulletin by Joy Manufacturing Company. These two- and three-drum haulers are designed for continuous heavy-duty operation. Designated Joy A and B class slushers, they feature fully self-energizing clutches and automatic brakes for operating ease. Other features, according to the manufacturer, include large, exposed clutch bands for cooler running, longer life, and simple adjustment; simplified lubrication and rugged, one-piece steel base. Also described are three different types of remote-control systems for Joy slushers. Write for free copy of Bulletin 76-J to Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.

BATTERY HANDBOOK AVAILABLE

Industrial storage battery users and maintenance men will be interested in a new 36-page handbook of technical instructions and engineering data on the care of motive-power storage batteries. Prepared by the Industrial Division of Gould-National Batteries, Inc., Trenton, N. J., the illustrated booklet, "Instructions and Maintenance Data" (GB-1896), covers all phases of battery theory, operation, and maintenance. It is available free of charge from the manufacturer.

CRAWLER CRANE-EXCAVATOR CATALOG

A new 24-page catalog describing a 40-ton crawler crane-excavator has been released by the American Hoist & Derrick Company, St. Paul, Minn. The catalog describes and illustrates the many time-saving features claimed by the company on its 500 series crawler. Copies of this new catalog on the American 500 series crawler crane-excavator of 40-ton capacity are available from the American Hoist distributors or direct from American Hoist & Derrick Company, St. Paul, Minn.

DRILLING SYMPOSIUM AT PENN STATE

Exploration drilling will be the topic of a three-day symposium to be held at Penn State on October 8 to 10. Jointly sponsored by the Departments of Mining Engineering at the University of Minnesota, Colorado School of Mines, and The Pennsylvania State University, this will be the ninth annual Drilling Symposium held since its inception at Minnesota in 1950.

Five technical sessions will deal with statistics and operations research in exploration, bit design and rock penetration, improving core recovery, drilling and sampling of unconsolidated materials, and innovations and case studies in drilling practice. The program should be of interest to engineers, geologists, contractors, and operators.

GEAR MOTOR BULLETIN

A new bulletin on gear motors has been issued by the Jones Machinery Division of Hewitt-Robins, Inc. The bulletin contains technical information on horizontal- and vertical-mounted gear motors with capacity up to 125 hp. and a variety of output speeds ranging from 780 r.p.m. to 1.2 r.p.m.

Included in the booklet is a load-characteristics table for application in various industries and different types of equipment, and a selection table arranged according to AGMA classifications. To obtain a copy, write to Hewitt-Robins, Inc., 666 Glenbrook Road, Stamford, Conn.

CHART CONVERSION FACTORS

A reference table in wall chart form has been published by Precision Equipment Company. This conversion chart is useful for engineers, shop men, and executives.

Included are common conversions such as inches to centimeters or watts to horsepower as well as many conversions that are difficult to locate in reference manuals.

For a free copy of the Conversion Factors wall chart write Precision Equipment Company, 4411E Ravenswood Avenue, Chicago 40, Ill.

RUBBER-MOUNTED MACHINES CATALOG

The Koehring Division of Koehring Company has just issued a catalog containing sixteen on-the-job and thirty-five assembly photos of its 205 rubber-mounted truck and Cruiser crane. A special section is devoted to the 205 truck and Cruiser chassis and upper machinery assemblies. Included in these sections are explanations and photos of the upper major shifts, complete with power flow diagrams, and an explanation of the enclosed gears.

A "Standard Equipment" section tells about pendant boom suspension, telescopic boom limit stops, automatic power boom lowering, and torque converter drive.

Copies of the 205 Rubber-Mounted Catalog can be obtained by writing to Koehring Division, Koehring Company, 3026 West Concordia Avenue, Milwaukee 16, Wis.

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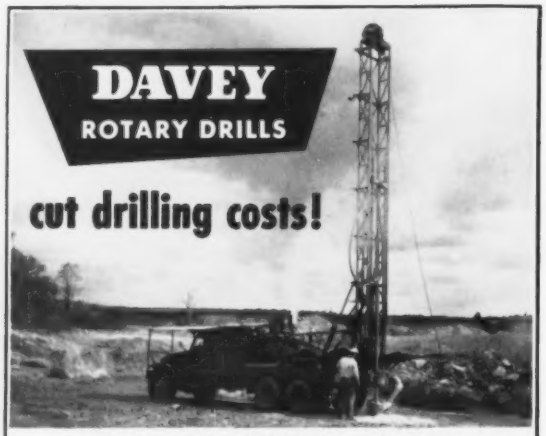

Davey Rotary Drill at Lingle Coal Co., Shawville, Pa.

For faster, more economical drilling . . . increased coal production at lower cost, leading strip operators rely on Davey. Suitable for mounting on any truck, Daveys move fast between blast holes . . . are easy to set in drilling position. Available in 8 models—air blast, mud pump, or combination. AA-1699

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pioneers of "air-cooled air"
DAVEY COMPRESSOR CO.
KENT, OHIO

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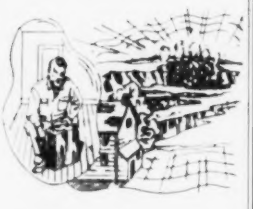

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B. F. Howell, Jr., Ph.D., P.E.
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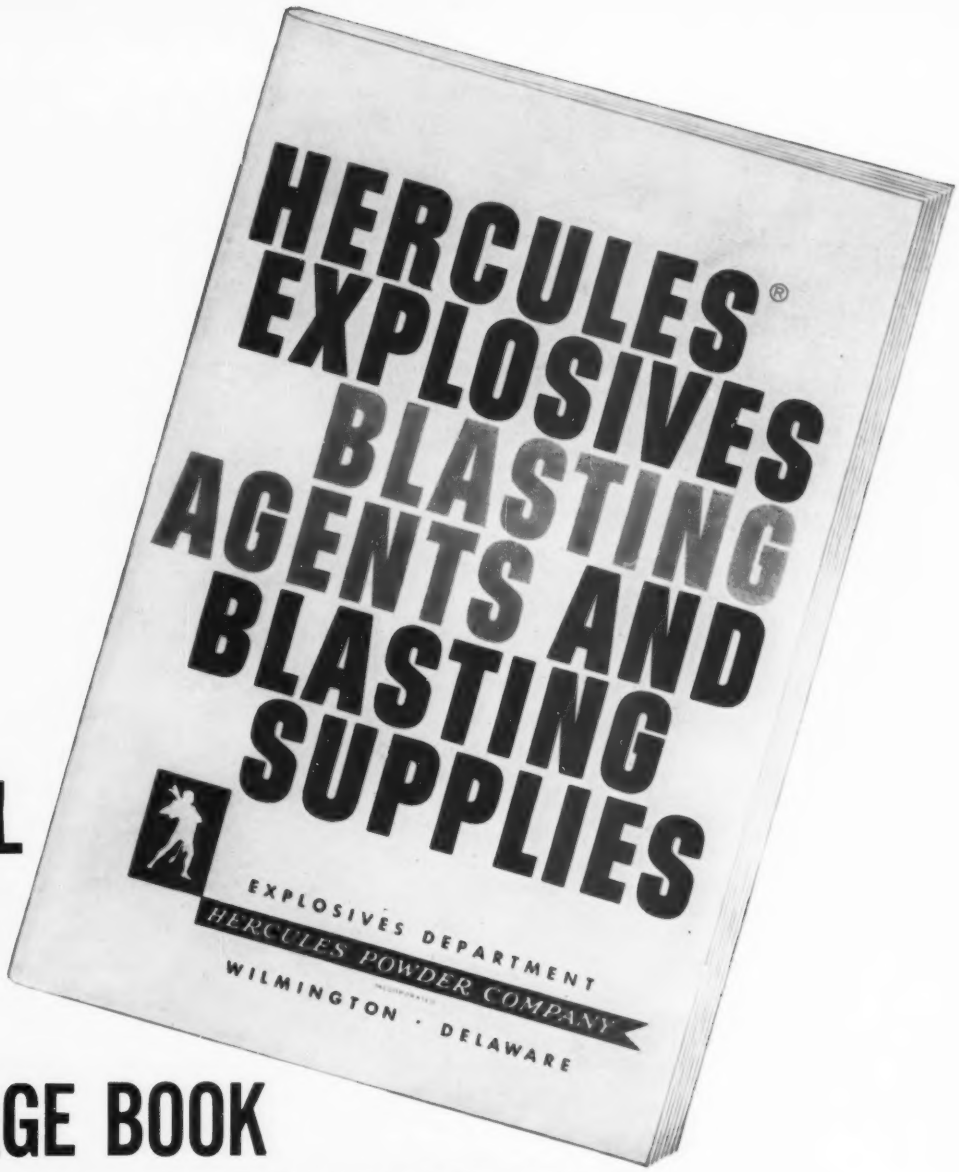

YOU'LL WANT THIS 80-PAGE BOOK FOR YOUR REFERENCE FILE

Since its inception, Hercules has been, and continues to be, a pioneer in the development of improved materials for the industrial explosives user. To help you choose the proper explosives, blasting agents, and blasting supplies, we have gathered the latest information and published it in a handy 80-page reference guide.

Complete with photographs, reference charts, and descriptions of Hercules Explosives, Blasting Agents, and Blasting Supplies, this guide was designed to provide you with an up-to-the-minute source of information on materials available for blasting, and their effective use. Send for your free copy today.

Explosives Department
HERCULES POWDER COMPANY
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900 Market Street, Wilmington 99, Delaware

HERCULES

In secondary blasting, it's a lot better to hook-up and ignite your safety fuse with *Quarrycord*

Prime with safety fuse and blasting caps. You'll play-it-safe two ways:

- No danger from stray electrical currents or thunderstorms.
- No big "boom!": you get a series of small shots: "pop-pop-pop".

Connect and ignite your safety fuse primers with Quarrycord and play-it-safe *again* because—

- No men on the rock pile. The entire blast is set off by *one* man at a point where escape is safe and easy.

Quarrycord is packed on spools in 100-ft. lengths. It is easily lighted with a match and burns with a very hot open flame at the rate of about one foot per second.

HOW TO USE QUARRYCORD

Cut your safety fuse in equal lengths as prescribed by your State law, and prepare your primer cartridges. On the end of the fuse opposite the blasting cap place a Connector. This is a metal tube containing an ignition compound in the slotted end, and color-banded for easy identification. Load and tamp the holes.

When ready to blast, connect all holes with Quarrycord, placing it in the slot of each Connector and pressing the "lid" down to hold the Quarrycord firmly in place and assist ignition.

Connect your main lines with cross lines wherever these will cut down the over-all burning time. Lead main lines off to a point away from the rock pile. When all is ready, light this end with a match and go to a place of safety.

It's quite a story, told completely in this folder which we'll send you, free, when you ask for it. Write today.

Your explosives supplier can supply Quarrycord and Connectors.

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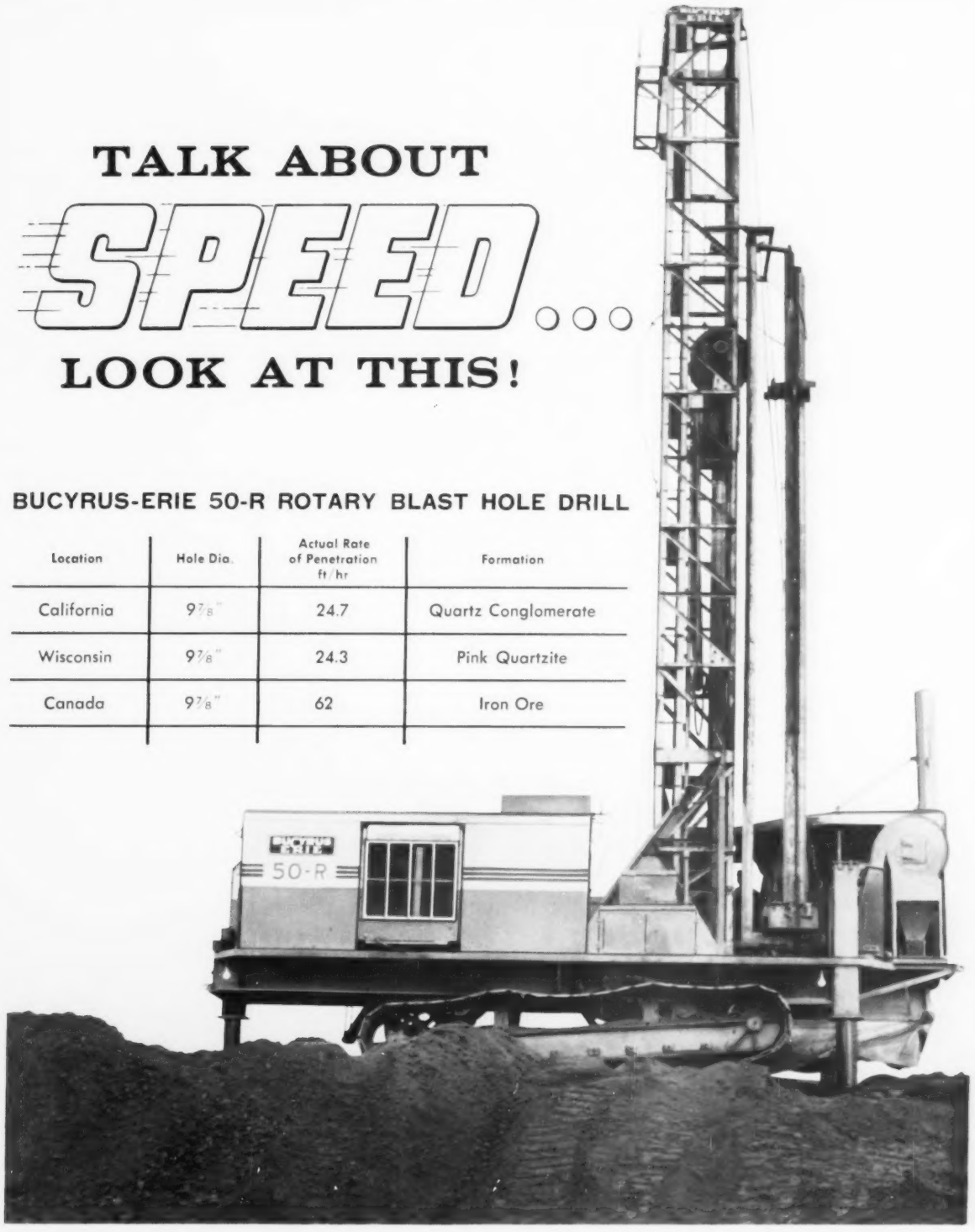

BUCYRUS-ERIE 50-R ROTARY BLAST HOLE DRILL

Location	Hole Dia.	Actual Rate of Penetration ft./hr	Formation
California	9⅞"	24.7	Quartz Conglomerate
Wisconsin	9⅞"	24.3	Pink Quartzite
Canada	9⅞"	62	Iron Ore

These are typical production figures reported to us by owners of 50-R blast hole drills. We think they speak for themselves. No wonder it's the most wanted blast hole drill in the business.

Write for complete details. Bucyrus-Erie Company, Drill Division, Richmond, Indiana, Dept. 12B.

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Ingersoll-Rand, the pioneer builder of portable rotary compressors, now offers a new size Gyro-Flo—the R-250 with a completely new, simplified compressor system.

The new Gyro-Flo 250 offers nearly 20% more capacity in a unit that is smaller and more compact than its predecessor—the Gyro-Flo 210. It is driven by larger, more-powerful engines—yet retains the same 1800 rpm engine speed. Fuel and air tanks are under housing and lockable cover...Full-length tool boxes give more storage space...There's provision for easy inspection of all rotor vanes...Side covers fold back safely out-of-way...And 12-volt battery system permits fast starting. These are just a few of the features of the new R-250.

The Gyro-Flo 250 gives you a choice of two compressor-matched drives—the *new* General Motors 4-53 diesel engine or the Continental M-363 gasoline engine. Available with 2- or 4-wheel mounting, or without running-gear. Ask your Ingersoll-Rand representative for complete information, or send today for Bulletin 2931.

DIMENSIONS AND WEIGHT

4-Wheel Mounting	G.	D.
Weight (wet)	4425	4610
Length (less drawbar)	8'-10½"	8'-10½"
Width	5'-9½"	5'-9½"
Height	6'-1"	6'8⅝"
2-Wheel Mounting		
Weight (wet)	4390	4575
Length (incl. dr'wbar)	12'-5"	12'-5"
Width	5'-11"	5'-11"
Height	6'-0⅝"	6'-8½"
Less Running Gear (Incl. Shipping Skid)		
Weight (wet)	3879	4064
Length	7'-8½"	7'-8½"
Width	3'-2"	3'-2"
Height	4'-5"	5'-9"

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